Developing a Community of Climate-Informed Conservation Practitioners to Protect a Priority Landscape in Illinois and Wisconsin

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Problem

There currently is a lack of adaptation strategies being implemented as part of existing habitat restoration and land-use efforts in coastal Illinois and Wisconsin. Bluffs and ravines nestled among the coastal communities along the Illinois and Wisconsin Lake Michigan shore are a unique habitat and priority for restoration. After the glaciers retreated from the area at the end of the ice age, streams flowing into Lake Michigan that eroded into the glacial, exposed lake-bed sediments and formed the ravines. Today the ravines are the remaining vestiges of the head-cutting of those streams. The approximately 47 ravines existing today represent Illinois' only drainage system naturally flowing to Lake Michigan (Figure 1). They are steep-sided, v-shaped valleys that create groundwater-fed growing conditions and microclimates, which in turn create unique communities of plants and animals (Figure 2). Ravines provide a multitude of habitats, and the diversity of natural communities

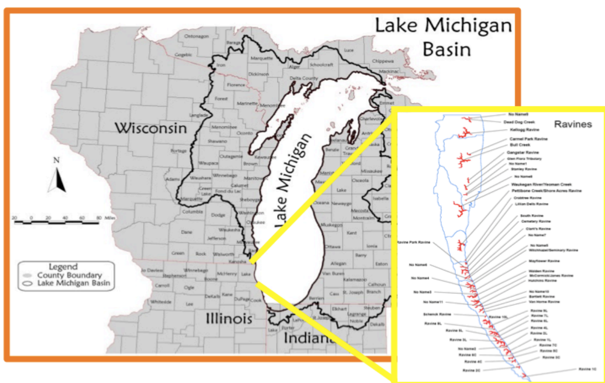

Figure 1: Map of the 47 ravines along the Illinois Lake Michigan coast, created as part of the Strategic Subwatershed Identification Process. All maps, along with the final report, can be found at: http://greatlakes.org/Page.aspx?pid=881.

Figure 2: Diagram of a ravine. 1) Buff, 2) Ecotone, 3) Gully, 4) Headward Erosion, 5) Moraine, 6) Ravine, 7) Seep, 8) Slump, 9) Streambed Armor; more information found at: http://www.chicagowilderness.org/CW_Archives/issues/fall2008/ravines.html

supported by this system illustrates the important role they play for native plants of concern, threatened and endangered species, and migratory and wetland birds. In addition to the environmental benefits, restored ravines help protect property values, drinking water quality, and recreational opportunities. While erosion created ravines, extreme erosion events resulting from surrounding land use threaten their stability and the plant and animal communities. Since 2010, Illinois has received over $7 million in federal Great Lakes Restoration Initiative funding for ravine conservation, much of which is focused on addressing erosion issues. This significant public investment could be at risk due to little consideration of future climate impacts. Incorporating adaptation strategies into ravine and watershed management in Illinois and Wisconsin can reduce risks to current and future ravine conservation efforts.

While most restoration practitioners and land/watershed managers agree climate change will impact Great Lakes coastal communities, there is still much uncertainty as to the scope of those impacts and, therefore, the appropriate management actions that can be taken. Given this knowledge gap, managers often feel they need more information before changing or reprioritizing their current practices. Since 2007, the Alliance for the Great Lakes (Alliance) has been facilitating, both formally and informally, a group of partners who recognize the importance of the ravines and are committed to implementing conservation-focused practices. These partners are the local "bridging organizations" (Bidwell et al. 2013), each with their own direct links within their community and to decision-makers. Through this project, we focused our outreach and capacity building on these local bridging organizations and people. Our facilitation work resulted in local organizations from different disciplines working together to: 1) identify how climate impacts could affect their ability to achieve their goals; 2) prioritize which adaptation strategies will most likely reduce their vulnerability to these impacts; and 3) implement the top adaptation strategies. Bringing the restoration community (e.g. forest preserves, park districts, ecologists, biologists) and those responsible for land-use and water-use infrastructure (e.g. public works, planning, sanitary districts, engineers) together to coordinate implementation is critical because the most effective solutions are ones that are both inter-disciplinary and inter-jurisdictional.

Approach

Our long-term goal is to develop a community of climate-informed practitioners committed to implementing both landscape-scale and jurisdiction-specific adaptation strategies to protect the ravines. Our core strategy is to build the capacity of local organizations and people so they can lead the implementation of these local climate-informed conservation practices, thus ensuring that climate change planning becomes integrated into routine land management decisions.

Network Mapping

A necessary first step is to prioritize where implementation will happen and identify the people with the authority to implement. Identification of the *natural network*, at landscape and local scales, allows planners and managers to prioritize certain locations for implementation and communicate the benefits of those specific strategies. Identification of the *social network* allows for targeted outreach by clarifying the agencies, organizations, and people who have the authority to implement land-use and restoration decisions; these are the individuals we must collaborate with to take action. When the natural and social networks are connected, people and organizations who own and/or manage key parcels of land in the natural network work together to implement policies, projects, and management practices. This increases the ability of the social and natural networks to adapt to changes.

Natural Network

Mapping and identifying the natural network at landscape and municipal scales is a foundational tool used for building consensus on priority areas to focus the implementation of climate-informed conservation practices**.** The goal of this process is to have a strategic communication tool that allows facilitators to target key parcels of land and land owners in order to collaboratively implement policies, projects, and practices that help ensure a connected and protected network of land at regional and local scales. A natural network is comprised of larger core areas that are protected or are high priorities for protection due to their ecological value, with corridors and buffers established to connect the core areas to each other. Chicago Wilderness[1] led a process that identified the natural network of land that is or should be protected (Figure 3). In 2009, the Alliance carried out a more locally focused process, the Strategic Sub-Watershed Identification Process (SSIP), that identified and quantified the quality and extent of habitat within several Illinois Lake Michigan subwatersheds (Boeckler et al., 2009) and ranked ravines based on their potential for erosion (Figure 4). Since 2009, the Alliance, municipalities, and other interested groups have used the SSIP to make informed decisions about where to focus resources in order to improve the ecology of the Illinois Lake Michigan watershed. While there are ideal standards for the size of core areas, corridors, and buffers in order to provide ecosystem services (e.g. riparian buffers that provide the service of bank stabilization which in turn improves water quality and aquatic habitat), the extent to which protections can be achieved is mainly driven by decisions made at the local level and based on existing land-use choices and political will.

Figure 3: Map of the Chicago Wilderness Green Infrastructure Vision, a regional landscape scale vision for an interconnected natural network of land and water resources.

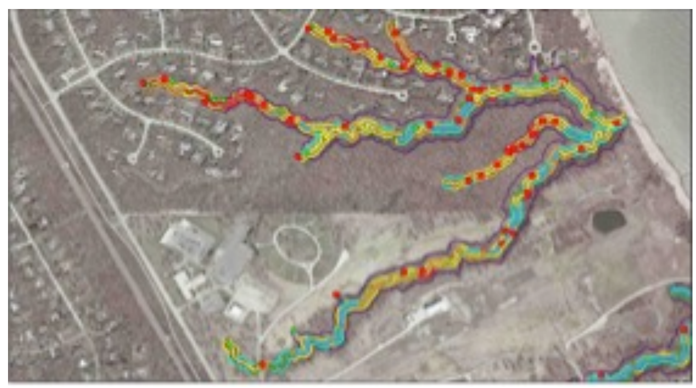

Figure 4: An aerial map of an Illinois ravine where data on erosion impacts was collected as part of the Strategic Subwatershed Identification Process. Detailed maps, along with the final report, can be found at: http://greatlakes.org/Page.aspx?pid=881.

Social Network

The authority to implement policies, projects, and practices lies with the local agencies, organizations, and individuals who own or manage land. These individuals make up the social network. Generally speaking, people work within a

[1] Chicago Wilderness is a regional alliance that connects people and nature, with more than 300 member organizations working together to restore local nature and improve the quality of life for all living things by protecting the lands and waters on which we all depend. http://www.chicagowilderness.org/

specific jurisdiction to achieve their organization's goals. Bringing these individual actors together to facilitate the development of shared goals and strategies, which works to strengthen the community of climate-informed conservation practitioners, is core to our facilitation strategy. Understanding the structure of the network, for example the composition of sub-groups and how collaborative information sharing occurs, is key to building a strong social network connected to the natural network.

In order to be effective, the facilitation and planning process begins with getting experts from different sectors together to identify shared goals. An important facet of effective engagement is identifying trusted local experts and working one-on-one with them to solidify their commitment to participate, usually as technical advisors, in the planning-to-implementation process. The strategy is to build the capacity of these technical advisors to be local champions who help lead the broader network. For this project, twelve individuals were invited to participate as technical advisors, four of whom received funding to provide data and information and two of whom committed to implementation. In addition, over 50 additional key stakeholders were identified and invited to participate (Appendix 1). Finally, we used social network analysis to establish a baseline for climate-informed behavior and inform the design of future facilitation strategies to more effectively implement climate-informed conservation strategies.

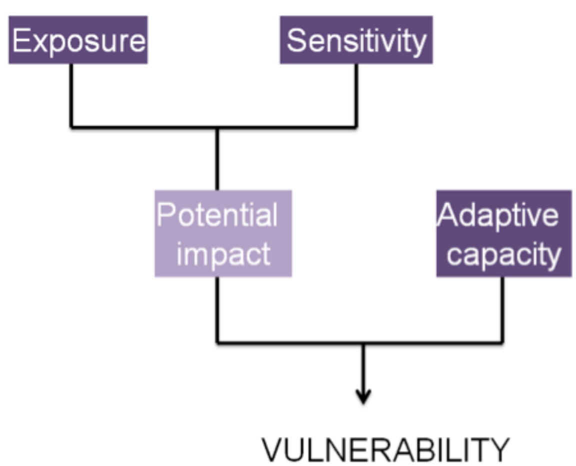

Figure 5: Visual example for discussing climate vulnerability (adapted from Schroter 2004).

Social network analysis has been applied in a variety of contexts – from understanding and predicting behavior and program effectiveness to the studies of resilience by linking social and ecological networks (Janssen et al., 2006). For more information on the social network analysis used, please see the *Evaluation* section of this paper.

Meeting Design

Implementation requires collaboration, coordination, and communication with local stakeholders, which in turn is largely achieved through good meeting design and facilitation. This project included a series of five meetings designed to promote a step-wise progression of information sharing and place-based application of climate science, expected climate stressors, and likely impacts to the ravine system on core management practices. The meeting series was intended to achieve the following goals: 1) set the stage and introduce the project; 2) build consensus on the goal for regional landscape restoration of coastal ravines that will serve as the cornerstone for the climate vulnerability assessment and the overarching guidance for developing adaptation strategies; 3) select adaptation strategies that local implementers are committed to leading; 4) strengthen the capacity of local experts (e.g. members of the technical committee) by providing needed tools and information to lead implementation of prioritized adaptation strategies; and 5) share and guide the broader social network through the process and outcomes via a webinar.

Planning with the Natural Network

The planning framework for this project drew on several climate adaptation planning guides, especially those focused on urban conservation, to develop a tailored planning framework for this audience and context (Derby Lewis, et al., 2012; Reeve, et al. 2014; U.S. EPA, 2014). After the local team of technical advisors was organized and convened, one of their first activities was to develop a ravine restoration goal for the regional landscape. The technical committee, and later the broader stakeholder group, came to the following consensus on the goal: *Restore ecological functions and environmental conditions that result in habitat for the unique assemblage of highly diverse floristic and faunal communities associated with coastal ravines*. Next, broad concepts related to climate vulnerability and adaptation were introduced (Figures 5 and 6), which were followed by an overview of the historic climate trends and downscaled climate projections for the region prepared by Great Lakes Integrated Sciences and Assessments Center (GLISA) (Appendix 2). Building on the historic data and future projections information, the next meeting focused on translating the anticipated climate stressors to potential impacts on the ravine system. Using a conceptual model of a ravine that separated out different ecological features of the system (Figure 2), the project's climate change ecologist facilitated a full group discussion before breaking into facilitated small group discussions. This process was intended to help "train our brains" to think through the process of how different climate stressors might independently impact ravine features and how interactions between stressors could play out in different ways. Expert opinion gathered in this fashion was then synthesized and sent back to the group for review (Appendix 3). After the broader group of stakeholders had the opportunity to provide feedback on how climate stressors will impact the ravines, the smaller group of technical advisors came back together to focus on which climate stressors and impacts were most critical to address. This decision was based on three equally important aspects: the landscape restoration goal; the management goals of the implementer's organization; and the implementer's capacity to address the impacts. Adaptation strategies aimed at reducing these climate impacts were then drafted. The strategies tended to focus on actions that could be taken near-term and were divided into two categories: those that an individual organization could implement and those that needed collective action. The last meeting with just the implementers resulted in a prioritization of adaptation strategies by two organizations committed to implementation (Appendix 4).

Implementation

While planning is vital to the process, the end goal is always implementation of climate-informed policies, projects, and management practices. As part of this project two local land managers, Lake County Forest Preserves and Openlands, committed to implementing the top adaptation strategies. As described in the *Planning Framework* section above, the Technical Committee developed a suite of adaptation strategies that spanned from the near-term (1- 5 years) to longer-term (11-15 years). The two organizations then decided which strategies they were committed to helping lead. Following this, all stakeholders participated in a webinar where they voted on which of the top adaptation

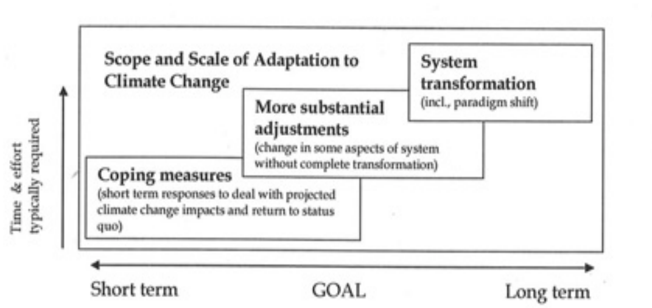

Figure 6: Example of climate concepts: Scope and scale of adaptation to climate change (from Moser and Ekstrom 2010).

strategies identified by the Technical Advisory group they wanted to help implement (APPENDIX 4). The top adaptation strategies will be used to guide future facilitation work with the committed implementers and broader network to continue to support the development of a community of climate-informed conservation practitioners.

Characterizing the Social Network

Purpose

Social network analysis is used to characterize the structure of the ravine network and the interactions between members of the network. This information will be utilized to develop targeted facilitation strategies focused on increasing the frequency of implementation of ravine adaptation practices in the project area (See *Application* and *Next Steps* sections for more details). The underlying assumption, one supported by theory and research, is that the most effective facilitation strategies are those that utilize the existing network, which means that it is critical to identify the people who are well integrated within the network and best positioned to influence and lead, and design facilitation strategies with the intent of building the capacity of these local leaders. The individuals in the ravine network are composed of land managers, decision makers, and technical experts responsible for natural resource protection and stormwater management along the coast in northeastern Illinois and southeastern Wisconsin. The characterization of this network is designed to illuminate: (1) the composition of sub-groups within the network; (2) the extent to which sub-groups are able to collaborate and share information about ravine management; (3) how and from whom land managers acquire information that informs their decision-making; (4) the extent to which climate adaptation is included in planning and implementing ravine management strategies; and (5) beliefs about lake levels and freeze thaw cycles more broadly in the Great Lakes.[2]

Methods

A survey instrument was developed that included questions about respondent's closest colleagues, the frequency of their interactions with these colleagues, and whether and to what extent respondents incorporated issues of climate change into core ravine management practices. In addition, the survey instrument asked questions regarding sources of climate change related information. The complete survey instrument is attached in Appendix 5. A set of 49 individuals involved in ravine conservation and management was identified as the outreach targets for the survey. We administered the survey face-to-face at one of the facilitated meetings (on 6/17/2014, 14 responses collected), and online (using Qualtrics) (from 7/30/2014 to 9/22/2014, 30 responses collected).

[2] Through the collaboration with Michigan State University and Great Lakes Integrated Sciences and Assessments Center, the survey also included the questions regarding lake levels and freeze thaw cycles in the Great Lakes, however, the reporting out on those results is beyond the scope of this paper.

After collecting the survey data (N = 44 responses), social scientists at Michigan State University developed four network maps (Figures 7-10). It is important to note that the network maps discussed below focus on stormwater management because stormwater related strategies are the top adaptation strategies for the ravine network; additional diagrams and strategies related to habitat management are available upon request. In order for the frequency of implementation of core practices at an individual and sub-group scale to be analyzed and measured over time, statements describing core practices were analyzed for reliability, which was shown to be sufficiently high to conduct the analysis [3]

Results

A sub-set of the survey data are discussed below and visually represented in Figures 7-10. In each figure, the following characteristics apply: 1) colored circles represent an individual person that was named as a "close college" by someone who filled out the survey; 2) circles are color coded according to four sub-groups; 3) sub-groups were formed based on individuals who interact most frequently with each other (Frank 1995, 1996); 4) the thickness of the lines between circles represents the frequency of interaction between those individuals; and 5) circle size represents frequency of an individual implementing ravine practices, with larger circles indicating more frequent implementation and smaller circles indicating less frequent.

Overall, based on how often individuals interact with one another, four subgroups were identified within the network (Figure 7). Additional information gleaned from the survey includes which sub-groups (Figure 8) and which individuals (Figure 9) are implementing stormwater management practices most frequently, the frequency of individuals implementing *climate-informed* stormwater practices, and who is providing individuals in the ravine network with climate change information (Figure 10). Figure 10 also illustrates a feeder network, represented by green circles. Some of the sources of climate change information are members of the ravine network (indicated by red lines), while some sources are individuals outside the network (indicated by blue lines). The thickness of the lines represents the frequency of interaction between the person receiving and the person providing climate change information. The arrows on the blue and red lines indicate the direction the information was transmitted. The feeder network depicted in Figure 10 demonstrates that members of sub-groups are not communicating very frequently with each other, or with members of other sub-groups, about climate change. For example, the grey and burgundy sub-groups have only a few red lines indicating infrequent communication about climate change.

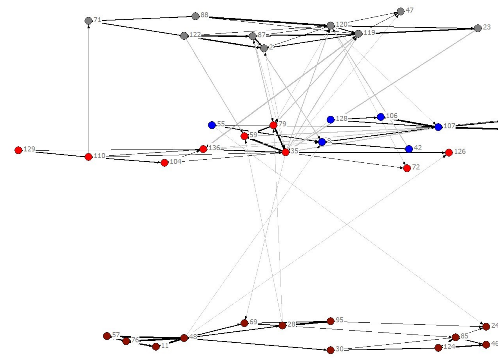

Figure 7: Social network map illustrates structure of the ravine network based on close colleague relationships. The network structure identifies: 1) members of sub-groups, 2) sub-groups that are closely connected, and 3) number and frequency (line thickness) of individuals' interactions with each other. Four (4) sub-groups are identified: grey, blue, red and burgundy. Individuals in these subgroups interact most frequently with each other, illustrated by the thickness of the lines between the circles.

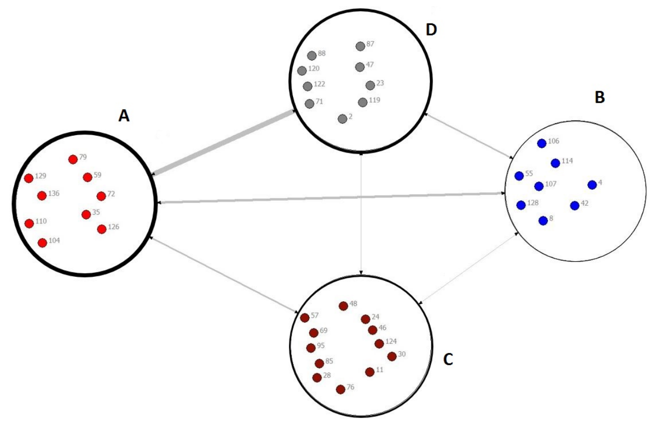

Figure 8: Social network map illustrates implementation frequency of stormwater management practices by each subgroup. On a scale of 0 to 4, subgroups have the following averages for frequency of implementation: red = 2.32; grey = 2.02; burgundy = 2.0; blue = 1.7. The thickness of lines between subgroups is proportional to the frequency of interactions between the subgroups.

[3] The reliability a for the ravine management practices are: stormwater management (a = 0.84); 2) habitat management (a = 0.82); 3) climate cha nge informed stormwater management (a = 0.89); and 4) cli mate change informed habitat management (a = 0.89).

Network Description

After identifying sub-groups based on close collegial ties within the network, it is possible to attribute sub-group composition based on the geography (e.g. which subwatershed members are working in) and sector (e.g. county and municipal government, regulatory, academic, non-profit) that most members of the sub-group represent. For example, members of the grey sub-group primarily work in the Bluff Ravine South watershed, and the sectors represented are mostly non-profit and academic with a few key municipal members. Members of the blue sub-group have the widest geographic range, covering almost the entire coastal zone in Lake County, Ill., including Bluff Ravine North and South, Waukegan River, and as far north as the Kellogg Creek watershed. In terms of sectors represented, the blue sub-group has significant expertise in stormwater management, but very few of the members have the authority to implement. Members of the red sub-group are individuals primarily working in the Waukegan River and Bluff Ravine North and Bluff Ravine South watersheds, which includes a strong inter-disciplinary mix of municipal, county, non-profit, and consultants, with several members having the authority to implement. The burgundy sub-group represents a very specific geographic focus – Bluff Ravine North watershed – and has municipal, non-profit and academic membership, representing a strong, inter-disciplinary mix of technical expertise, and implementation authority.

Application

Network analysis is being used to guide the development of facilitation strategies with the goal of increasing implementation of climate-informed ravine management practices through building the capacity of local leaders. The execution of these facilitation strategies will be led by the Alliance over the course of the next year, after which members will be resurveyed to evaluate the success of the facilitation. Generally, facilitation strategies will focus on: (1) ensuring sub-groups have members with the authority to implement; (2) strengthening interactions between key members of the sub-group with the lowest frequency of stormwater implementation (i.e. blue and grey sub-groups) and the sub-group with the highest frequency of stormwater implementation (i.e. red sub-group), which will require increasing the frequency of interactions between identified members of each of these sub-groups; and (3) identifying individuals that provide climate change information, both those who are already members of the network and those outside of the network, and increasing the frequency of their interactions with sub-groups focused on implementation.

For example, the blue sub-group, whose members have the most technical stormwater expertise, is self-reporting the lowest frequency of implementing climate-informed

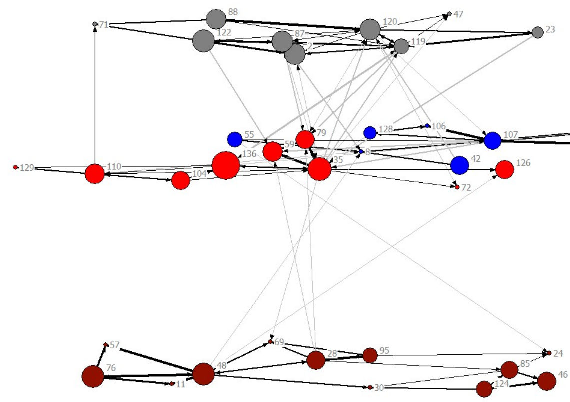

Figure 9: Social network map illustrates implementation frequency of stormwater management practices by individuals. Larger circle sizes reflect a higher frequency.

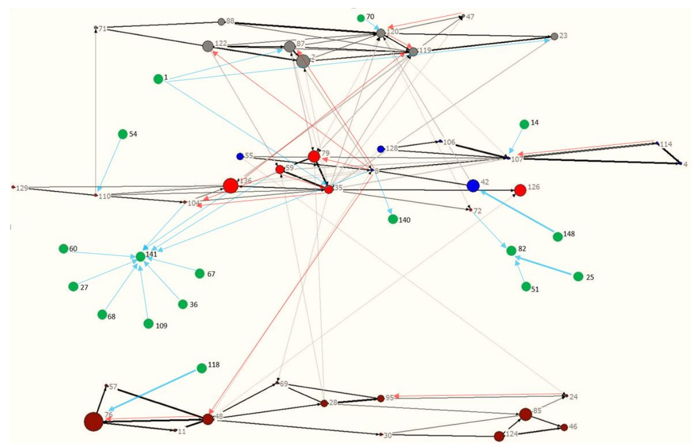

Figure 10: Social network map illustrates frequency of implementing climate-informed stormwater practices by individuals. Green circles, connected by blue lines indicate the individuals outside of the close colleague network responsible for providing climate change information being used to inform practices. Climate change information is also shared among the members of the ravine network as indicated by red lines. The thickness of the lines represents frequency of interaction between the person receiving and providing climate change information. The arrows on the blue and red lines indicate the direction the information was received..

stormwater best management practices. A couple of reasons why the blue sub-group may not be implementing

as frequently may be because members do not have the authority to implement stormwater management practices and/or are not interacting very frequently with members of other sub-groups. A future facilitation strategy will likely focus on expanding membership to include implementers (e.g. agencies who have the authority to implement stormwater best management practices) and strengthening interactions between members of the blue sub-group and members of other sub-groups to ensure the blue group's technical expertise is supporting implementation activities. In regards to climate adaptation, a possible facilitation strategy will likely be to identify members of the blue sub-group who are already providing climate change information and work on building their capacity to play a leadership role in the implementation planning process. For additional details on more specific facilitation strategies see *Next Steps*.

Next Steps

Facilitation

In regards to implementation, the Alliance's role is the continued support of a community of climate-informed conservation practitioners who in turn can lead the implementation of adaptation strategies. Continued facilitation of the network is needed to increase the number of practitioners embedding climate considerations into core management practices and to ensure that implementation is achieved because there is not yet a critical mass of local experts leading the integration of climate planning into their routine management decisions.

Stormwater

Addressing upstream stormwater impacts was one of the top adaptation strategies identified by partners (Appendix 4), due to high confidence that the occurrence of extreme storm events will increase. Further, without addressing upstream impacts, any downstream efforts are at significant risk. The Alliance will work with implementation partners to narrow the geographic focus and identify a handful of specific ravines and parcels where stormwater best management practices can be implemented, and work with land owners to get projects implemented. Key local partners will include: Openlands, Lake County Stormwater Management Commission, municipal planners, engineers, residential landowners and regulators to identify actions that will most effectively address upstream stormwater impacts in the identified and mapped ravine drainage basins. Over the next year the Alliance will facilitate a series of one-on-one and group meetings that culminate in an integrated, designed-based, all-day workshop in Fall 2015.

Habitat

Ensuring unique and rare ravine genotypes are available for conservation efforts is vital to protecting the ravine habitat's genetic diversity. A top adaptation strategy identified by partners is the development of a regional seed-sourcing policy to promote interagency seed sharing (Appendix 4). Lake County Forest Preserves, with the support of the Alliance and other partners, will be leading this effort.

Monitoring

The continued identification, reporting, and mapping of new invasive species on both public and private lands, in addition to water quality monitoring during and immediately after storm events and major winter thaws, are the top monitoring and baseline data collection strategies (Appendix 4). The Alliance, Conserve Lake County, The Field Museum and other partners are working with professors and researchers to develop long-term monitoring and student-driven projects that build on the adaptation strategies in Appendix 4 and can be used by land managers to inform future management decisions.

Evaluation

The Alliance and researchers from Michigan State University will re-survey the ravine network members during Fall 2015 in order to secure longitudinal data, which will be used to evaluate whether the executed facilitation strategies have resulted in increased implementation of ravine management practices.

Discussion and Lessons Learned

This facilitated process offered an opportunity for participants to begin training their brains in how to consider climate impacts to a particular system, connect this information to specific restoration and management goals, and then collaboratively develop adaptation strategies. The process is intended to be iterative and translatable to different projects and natural systems. It is worth noting in this project that while the technical team and broader stakeholder group did consider climate change impacts that are possible over a longer time horizon, the resulting planning and implementation timelines ultimately did not progress beyond a 3-5 year timeframe. Most of the adaptation strategies developed focused on near-term and "no regret" work that needed to occur anyway. This may represent a generalized outcome for other adaptation projects, in that new information is being provided and considered, but the strategies selected in the first iteration of climate adaptation development will most likely align with what practitioners are already doing and are most confident in implementing. It remains to be seen whether and how management might begin to shift focus from strategies best characterized as resistance to those more fully representing strategies for resilience or even transformation (e.g., Figure 6).

This project provided a mechanism to re-start conversations around previously identified management needs, such as developing a seed source policy and exchange program, from the perspective of climate change. Finding examples of existing management strategies that can "count" as adaptation to help illustrate what adaptation looks like, which is often described in vague or extremely high-level language, can be useful to jumpstart dialogue and build interest in the project outcomes. It can also help underscore that existing restoration approaches and tools can remain the same, but a new perspective will enable us to better apply them to meet future challenges (Harvey et al. 2013).

An important lesson for those leading a facilitated process to develop climate adaptation strategies is to be aware the outcomes will largely reflect the cultural values of the conservation practitioners. The question of how to adapt to a changing climate is informed by science, but will be shaped by the value system of a given community. For example, while climate models can help to inform which species are not likely to remain in a region over the long-term (e.g., species at the southern edge of their range or those dependent on microclimates not likely to remain under future conditions) practitioners may still decide to put resources into managing these species. Wildlife and other aspects of the natural world often represent one's sense of place, and as such they play a prominent role in driving management decisions (EPA 2002). Understanding and respecting values, and not attempting to pre-determine which strategies should be developed or prioritized, is a key element to successfully engaging natural resource managers in meaningful dialogue, and can ultimately improve the chances for successful long-term conservation action.

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Appendix

Appendix 1

Affiliation	Technical Committee Member	Attended at least 1 meeting and/or participated in the network survey
Lake Forest College		X
Lake County Forest Preserves		X
Northwater Consulting	X	X
Root-Pike WIN	X	X
Santec		X
Lake County Planning, Building and Development Dept		X
City of Zion		X
Openlands, Lakeshore Preserve	X	X
Davey Resource Group		X
Illinois Natural History Survey, Prairie Research Institute		X
Village of Winthrop Harbor/North Point Marina		X
Waukegan Citizen's Advisory Group		X
Winthrop Harbor Parks & Recreation		X
Chicago Botanic Garden, Plants of Concern Program	X	X
City of Lake Forest Parks & Recreation		X
Park District of Highland Park	X	X
Leauge of Women Voters		X
City of Waukegan, Dept of Planning & Zoning		X
US Army Corps of Engineers		X
Bull Creek Stakeholders Association		X
Illinois-Indiana Sea Grant (IISG) College Program		X
Lake County Forest Preserves		X
Alliance for the Great Lakes	X	X
Illinois Coastal Management Program	X	X
Lake Forest Open Lands Association		X
Openlands	X	X
Lake County Forest Preserves	X	X
Lake Bluff Open Lands Association		X
Northeast Illinois Invasive Plant Partnership	X	X
Openlands		X
City of Lake Forest Parks & Recreation		X
Living Habitats		X

Lake County Stormwater Management Commission	X	X
Milwaukee County Parks	X	X
Milwaukee County Parks		X
City of Lake Bluff		X
Lake Bluff Park District		X
Waukegan Citizen's Advisory Group		X
Lake Forest Open Lands Association		X
V3 Companies		X
Park District of Highland Park		X
City of Lake Forest Parks & Recreation		X
Illinois Beach State Park		X
Lake County Stormwater Management Commission		X
Schlitz Audubon Nature Center	X	X
Conservation Research Institute		X

Appendix 2

LOCALIZED CLIMATE INFORMATION
FOR IL AND WI RAVINES

Historical and projected future climate trends for the Illinois and Wisconsin Ravines located between Chicago, IL and Milwaukee, WI along Lake Michigan are summarized in this report. The Ravines area is located within the Southeast climate division in Wisconsin and the Northeast climate division in Illinois.

Map of IL/WI Ravines area (circled)

Regional and Local Climate Summary

The climate divisions in which the Ravines are contained have seen increases in annual air temperature and precipitation. These increases have not been consistent throughout the year. Temperature increases have been largely observed in winter and spring. While summer and fall temperature increases have been substantially smaller.

Precipitation has increased over both climate divisions that enclose the Ravines annually. Seasonally, precipitation has increased in both divisions the most in the winter and fall. During spring and summer increases have been less, with spring precipitation in NE Illinois decreased slightly over the period.

Table 1: Summary of observed climate change statistics for the Southeast Wisconsin and Northeast Illinois climate divisions. Changes are for the 1951-1980 to 1981-2010 time period.

	Annual	Winter	Spring	Summer	Fall
NE Illinois					
Temperature (°F)	1.13	2.27	1.32	0.55	0.59
Precipitation (%)	5.70	10.54	-0.39	2.32	15.65
SE Wisconsin					
Temperature (°F)	1.13	2.51	1.27	0.43	0.46
Precipitation (%)	7.34	14.75	5.63	3.29	11.98

Temperatures in Lake Michigan have risen during the summertime and lake ice levels have declined during the winter, though there is significant interannual variation.[1,2,3] Increased water temperatures and ice cover declines have the potential to alter the near-shore climate through increased evaporation and potential for increased lake effect snowfall. Though lake effect snowfall is less common on the windward side of Lake Michigan.

Future climate information for the Ravines area comes primarily from global and regional climate models (GCMs and RCMs). In the Midwest, the GCMs project a wider range of temperature and precipitation outcomes than the RCMs, so some of the values reported here are be beyond what is shown in the RCM-based maps. No model perfectly simulates the physics that govern global, regional, and local climate, so several models are consulted[4] to describe potential climate changes in the Midwest and the Ravines area.

Table 2: Summary of projected climate changes for the Midwest with localized descriptions for the Ravines area

		Short Term (2021-2050)	Long Term (2041-2070)
Annual	Temperature	Midwest ranges from 1.5-4.5°F warming with an average around 3°F.	Midwest ranges from 3-5°F warming with an average around 4.5°F. Warming is consistent across most of the Midwest.
	Precipitation	Midwest ranges from -4% to +7% change.	Midwest ranges from -7% to +12% change. The Ravine area is located on the edge of projections that show average increases as great as 8% and as low as 4%.
Winter	Temperature	Midwest ranges from 2-5°F warming with an average around 3.5°F.	Midwest ranges from 3.5-7°F warming with an average around 5°F in the Ravines area.
	Precipitation	Midwest ranges from -3% to +15% change.	Midwest ranges from -3% to +17% change. Winter has the greatest projected precipitation increases for the Ravines area (+10 to 15%). More precipitation will fall as rain.

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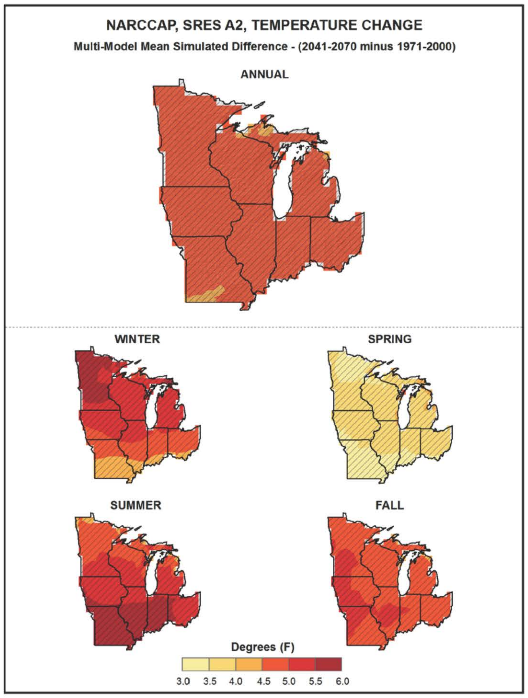
Spring	Temperature	Midwest ranges from 1-5°F warming with an average around 3°F.	Midwest ranges from 2-7°F warming. Temperatures in the Ravines area are projected to increase slightly more than surrounding areas. Spring has the least amount of seasonal warming.
	Precipitation	Midwest ranges from +2% to +10% change.	Midwest ranges from -5% to 15% changes in precipitation. The average change in the Ravines area is +5% to +10%, but some models show negative change.
Summer	Temperature	Midwest ranges from 1.5-5.5°F warming with an average around 3.5°F.	Midwest ranges from 2.5-9°F warming. Summer warming in the Ravines area is similar to winter warming (5°F on average).
	Precipitation	Midwest ranges from -13% to +11% change.	Midwest ranges from -23% to 19% changes in precipitation. The Ravines area sits at the boundary -5% to +5% change on average, so the direction of the future trend is uncertain.
Fall	Temperature	Midwest ranges from 1.5-4.5°F warming with an average around 3°F.	Midwest ranges from 3-6.5°F warming with an average around 5°F. Warming across northern IL and all of WI is consistent.
	Precipitation	Midwest ranges from -4% to +7% change.	Midwest ranges from -8% to 12% changes in precipitation. The Ravines area has an average of +5% to +10% change.
Extremes	Temperature		Projections indicate there will be up to three fewer weeks with below freezing temperatures and days above 95°F will stay the same or increase by up to 10 days per year. Consecutive days above 95°F will remain the same or increase by a few days per year.
	Precipitation		There is great uncertainty in extreme precipitation projections, but days with greater than 1" precipitation events are projected to increase. Consecutive dry days are projected to either increase or decrease by a few days in the Ravines area.

On an annual and seasonal basis all models indicate warming temperatures, but models start to diverge from one another in mid- (2041-2070) to late-century (2070-2099) projections. On average, annual temperatures across the Midwest are projected to increase by about 4.5°F by the mid-century. In the near term, temperature increases are projected to be less.

Regional differences start to emerge when seasonal temperature changes are considered. In winter, the greatest warming is projected for the northern Midwest. Spring temperatures show the least amount of warming, but the Ravines area may experience slightly more warming than the surrounding area. Summer temperature increases across the Midwest range from 2.5°F to 9°F and fall shows increases of 3°F to 6.5°F. Summer temperatures are projected to increase the most in the southern Midwest, and the average increase in the Ravines area is about 5.5°F. Fall temperatures are projected to increase the most in the western Midwest, and temperature increases in the Ravines area average about 4.5°F.

Average temperatures are warming, but fewer cold days are expected than more hot days. Days below freezing are projected to decrease, but temperatures in the Ravines area are buffered by Lake Michigan so decreases are not as large for the Ravines area compared to inland. On average the Ravines area is projected to experience up to three weeks less per year of days below freezing, but those days are not necessarily consecutive. Therefore, there is potential for an increase in the number of freeze-thaw cycles experienced.

Days with maximum temperatures above 95°F are projected to increase by 10-20 days on average in the Ravines area. However, only a small fraction of days above 95°F will occur consecutively, if at all.

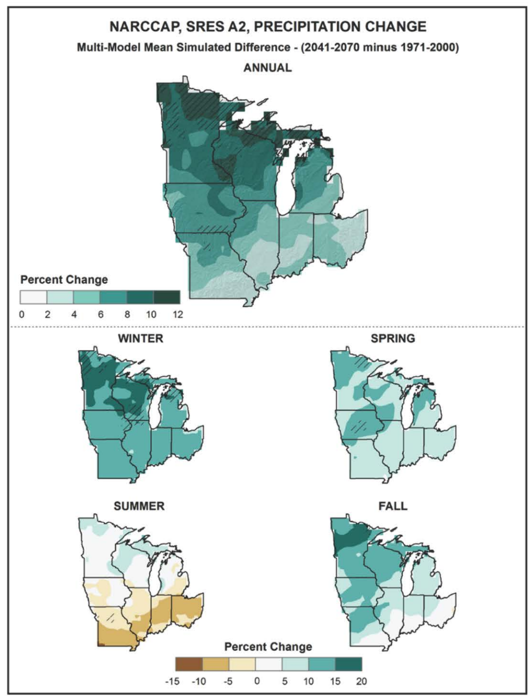


Projected annual and seasonal temperature changes for mid-century in the NARCCAP climate models. Image source: NOAA Midwest Technical Report Figure 30[5]

Precipitation trends across the Midwest vary depending on the season. Northern parts of the Midwest have the greatest projected average increase in precipitation. The Ravines area is projected to have slight increases (+4% to +8%) on average.

A major difference from the temperature projections discussed above is that the models are in less agreement about future precipitation amounts. Over most of the Midwest less than half of the models agree on the direction (+/-) of precipitation changes. The model averages indicate increasing precipitation for the Ravines area during winter, spring, and fall, although there is at least one model during every season that projects the opposite trend. There is especially high uncertainty for summer precipitation projections since the global climate models range from 20% reductions in precipitation to 20% increases in precipitation for the Midwest, and the regional models range from +/-10% changes. Fall projections have similar disagreements but to a lesser degree.

Projecting extreme precipitation events is challenging, because the models do not simulate the intensity of individual events well. The model averages indicate the number of days with greater than one inch of precipitation will increase in the future across most of the Midwest, but the Ravines area shows smaller increases than areas farther north in Wisconsin and Minnesota. The maximum number of consecutive dry days (days with less than 3mm precipitation) that contribute to drought conditions does not show a clear trend in the Ravines area. Most of the models indicate no significant change.

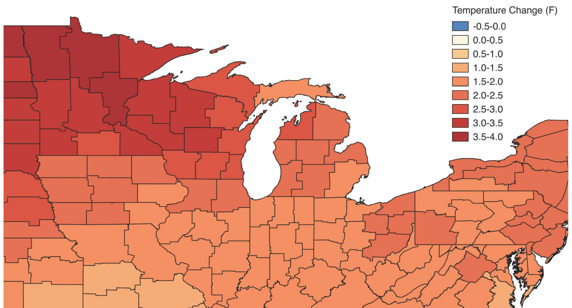


Projected annual and seasonal precipitation changes for mid-century in the NARCCAP climate models. Image source: NOAA Midwest Technical Report Figure 41[6]

Local Climate Differences

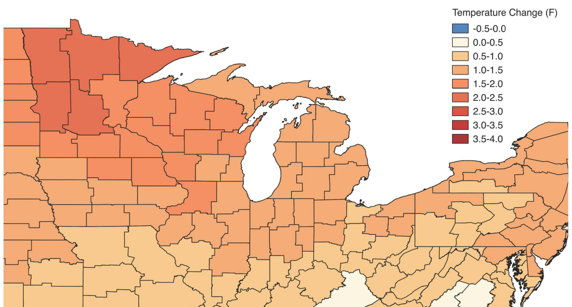
The maps and discussion that follow highlight how recent climate changes in the Ravines area differ from regional climate changes[7].

Winter Mean Temperature Change
1951-1980 to 1981-2010



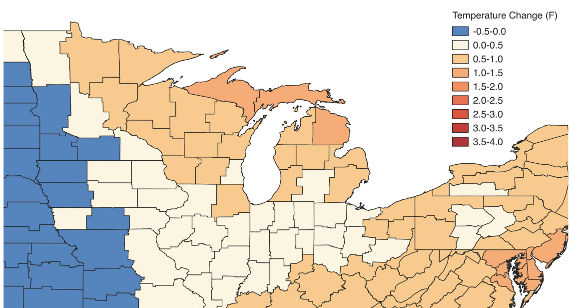
Winter temperatures have risen the most out of the four seasons for these two climate divisions. SE Wisconsin has warmed by 2.51°F and NE Illinois has warmed by 2.27°F on average. Though wintertime temperatures have warmed in these regions, seasonal snowfall amounts have not seen a clear positive or negative trend. This is interesting, as northern areas of the Midwest have seen increases in annual snowfall while more southerly portions of the Midwest have observed decreases.[8]

Spring Mean Temperature Change
1951-1980 to 1981-2010



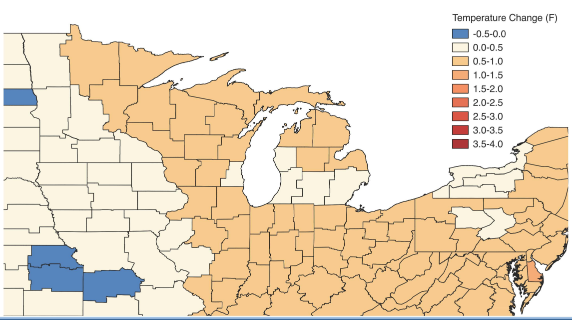
Spring temperatures have warmed approximately 1.3°F for each of the Ravines area climate divisions. This is similar to the warming observed in other climate divisions along the western shore of Lake Michigan.

Summer Mean Temperature Change
1951-1980 to 1981-2010



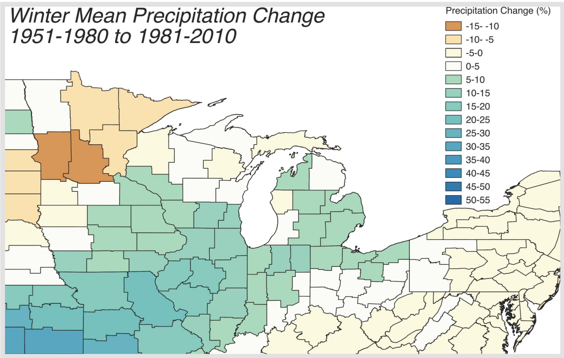
Summer temperatures have not increased as substantially as winter or spring (~0.5°F) in either Ravine climate division over the period from 1981-2010 when compared to 1951-1980. This is fairly consistent with other locations across the Midwest. This has been often referred to as the Midwest "Warming Hole".

Fall Mean Temperature Change
1951-1980 to 1981-2010

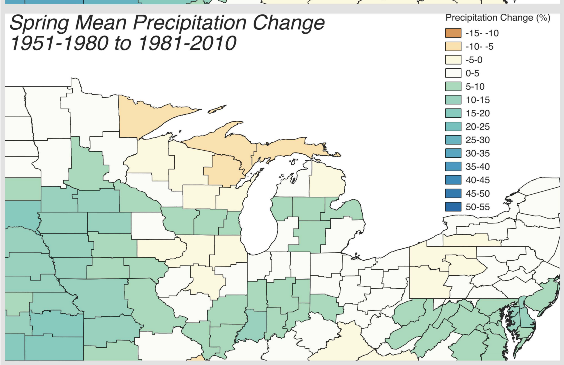


Fall temperatures increased similarly in magnitude to summer. Changes have been similar across most of the Midwest in the fall.

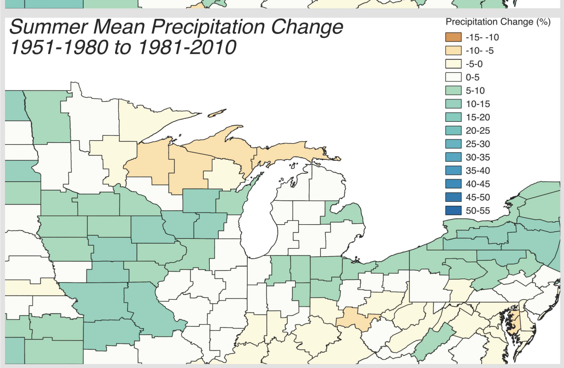
LOCALIZED CLIMATE INFORMATION FOR IL AND WI RAVINES



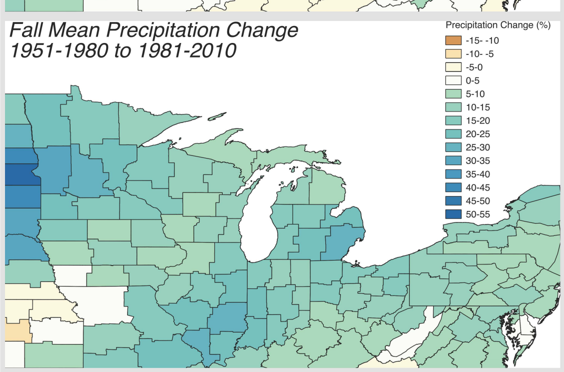
Winter precipitation along the southwestern shore of Lake Michigan has increased by over 10% in each of the Ravine climate divisions relative to the 1951-1980 normal period. Since snowfall amounts have stayed relatively steady across the region, the increases in precipitation may be attributable to increase moisture content in snowfall or more precipitation falling as rain during the winter months, due to urban heat island effects or warming of the larger scale climate.



Spring precipitation in NE Illinois has been essentially flat (-0.39%), while SE Wisconsin has increased slightly 5.63%. This is similar to much of the Midwest, where precipitation changes have been mixed. These changes are likely within the range of natural variability.



Summer changes in the region were small with both climate divisions reporting very slight increases in precipitation. Similar to spring, these changes are likely within the range of natural variation



Fall precipitation has generally increased across the Midwest; there are not strong differences between SE Wisconsin/ NE Illinois and the rest of the region. NE Illinois fall precipitation has increased 15.66%, while SE Wisconsin has increase 11.98%

References

[1] Gronewold, Andrew D., and Craig A. Stow. "Water Loss from the Great Lakes." Science. 343.6175 (2014): 1084-1085.

[2] Wang, Jia, et al. "Temporal and Spatial Variability of Great Lakes Ice Cover, 1973-2010." Journal Of Climate. 25 (2012): 1318-1329.

[3] Austin, Jay A., and Steven M. Colman. "Lake Superior summer water temperatures are increasing more rapidly than regional air temperatures: A positive ice-albedo feedback." Geophysical Research Letters. 34 (2007).

[4] The models consulted include those from the Coupled Model Intercomparison Project (CMIP) version 3 and the North American Regional Climate Change Assessment Program (NARCCAP) regional climate models. The "high" emissions scenario (SRES A2) projections were used.

[5] "Regional Climate Trends and Scenarios for the U.S. National Climate Assessment Part 3. Climate of the Midwest U.S." (2013). Available at: http://www.nesdis.noaa.gov/technical_reports/NOAA_NESDIS_Tech_Report_142-3-Climate_of_the_Midwest_U.S.pdf

[6] "Regional Climate Trends and Scenarios for the U.S. National Climate Assessment Part 3. Climate of the Midwest U.S." (2013). Available at: http://www.nesdis.noaa.gov/technical_reports/NOAA_NESDIS_Tech_Report_142-3-Climate_of_the_Midwest_U.S.pdf

[7] The maps are based on the nClimDiv Dataset (http://www.ncdc.noaa.gov/monitoring-references/maps/us-climate-divisions.php), which is a Federal data product for climate division data.

[8] Andresen et al. 2013. "Historical Climate and Climate Trends in the Midwestern USA" (2013). Available at: http://glisa.umich.edu/media/files/NCA/MTIT_Historical.pdf